(12) UK Patent Application (19) GB (11) 2 341 691 (13) A

(43) Date of A Publication 22.03.2000

(21) Application No 9922114.5

(22) Date of Filing 17.09.1999

(30) Priority Data
(31) PI9804296 (32) 18.09.1998 (33) MY

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(51) INT CL[7]
G01R 31/36

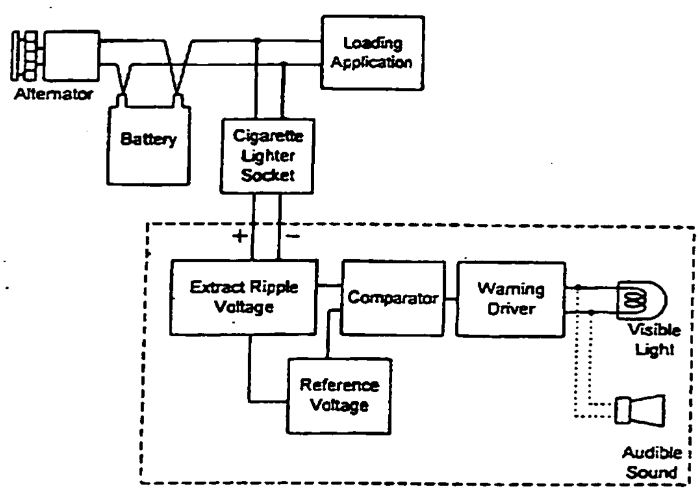
(52) UK CL (Edition R)
G1U UR3136

(56) Documents Cited
GB 2271229 A JP 100020002 A JP 090121472 A
US 5744932 A

(58) Field of Search
UK CL (Edition Q) G1U UR3100 UR3136, H2K KSX
INT CL[6] G01R 31/00 31/36
Online: EPODOC JAPIO WPI

(54) Abstract Title
Method and apparatus for automotive battery condition indication

(57) A system for monitoring the electrical condition of an automotive battery in use. This invention monitors and indicates liquid electrolyte level and level of battery plate deterioration using the concept of ripple voltage. Ripple voltage present in a battery supply line is utilised as a reference to deduce the condition of the battery. The method comprises measuring the ripple voltage present in the battery supply line when the engine is running, comparing the ripple voltage to a range of acceptable values, determined by an allowable extent of battery deterioration before issuing a signal or by nominal setting that best fits automotive vehicles, and lastly providing an indication when the ripple voltage exceeds the range of pre-set values. The apparatus comprises a ripple voltage detector, having the acceptable range setting, connected to the battery supply line, and an indicator connected to the ripple voltage detector which gives an indication when the ripple voltage exceeds the acceptable range setting.



Automotive Battery Monitor Circuit Adapted for Car
Figure 7

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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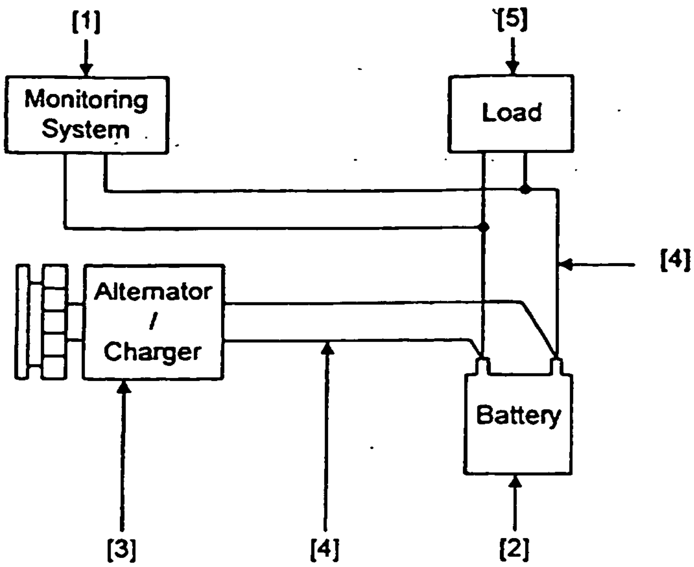

Figure 1

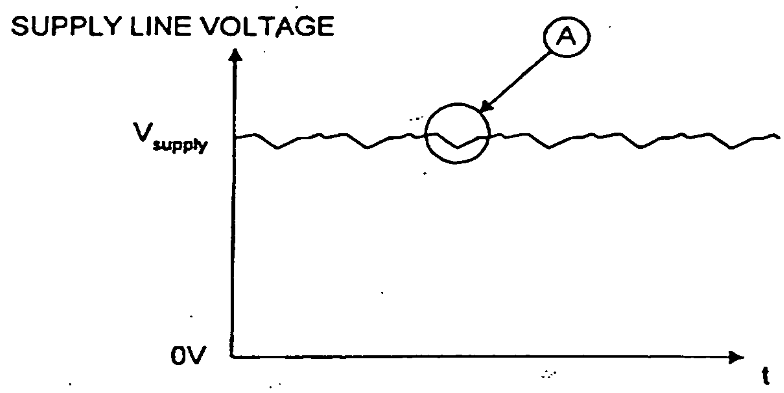

Figure 2

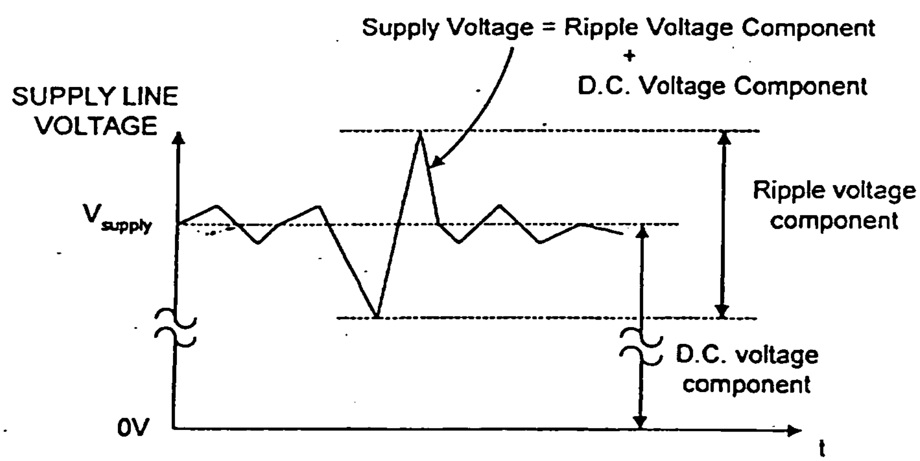

Figure 3

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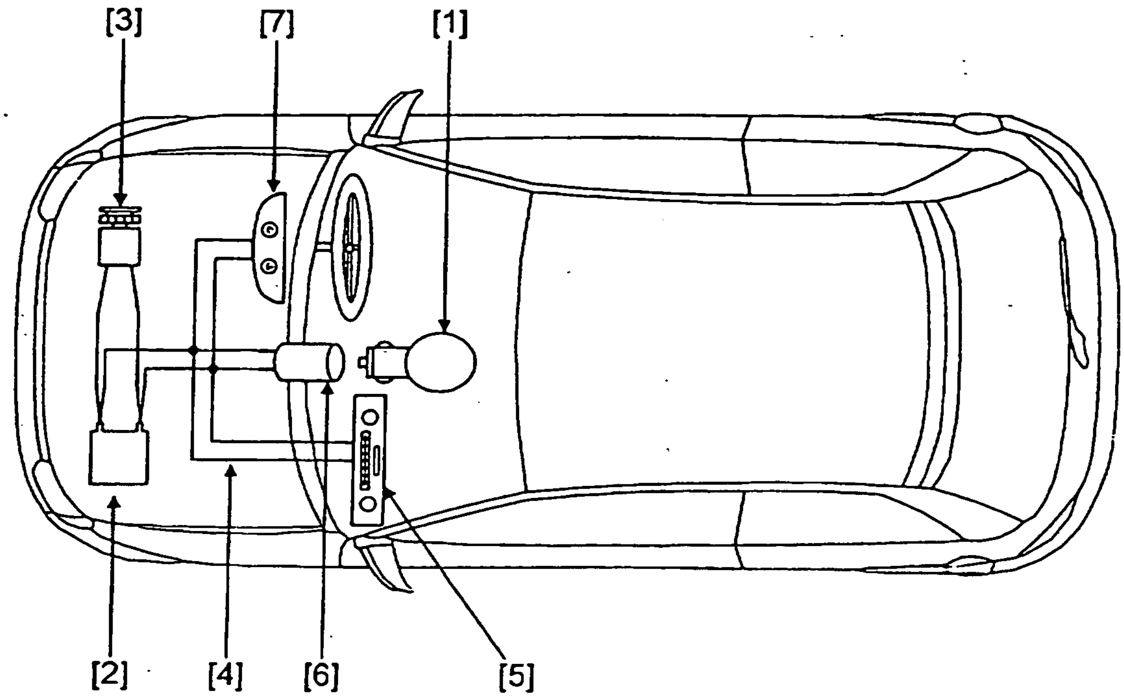


Figure 4

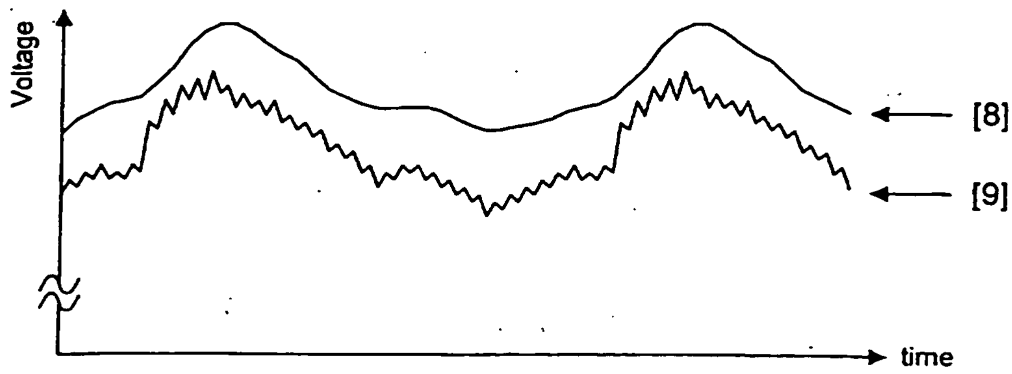


Figure 5

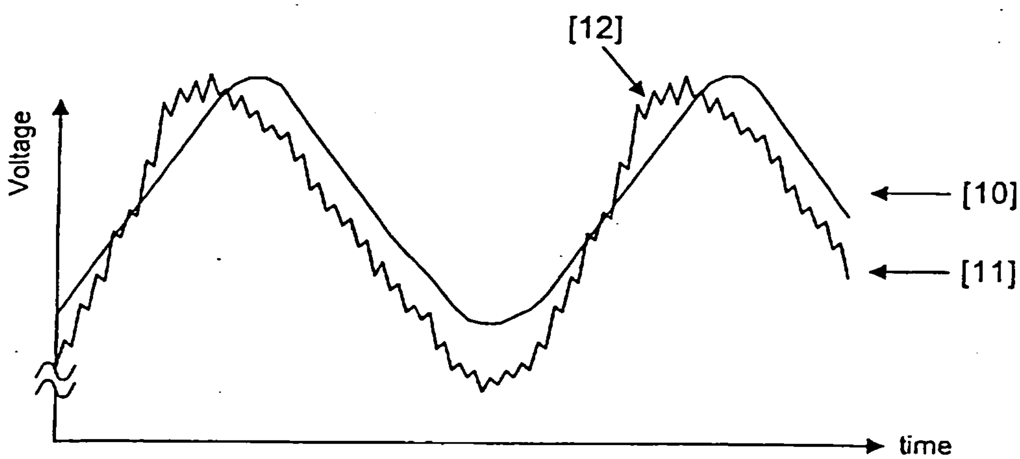
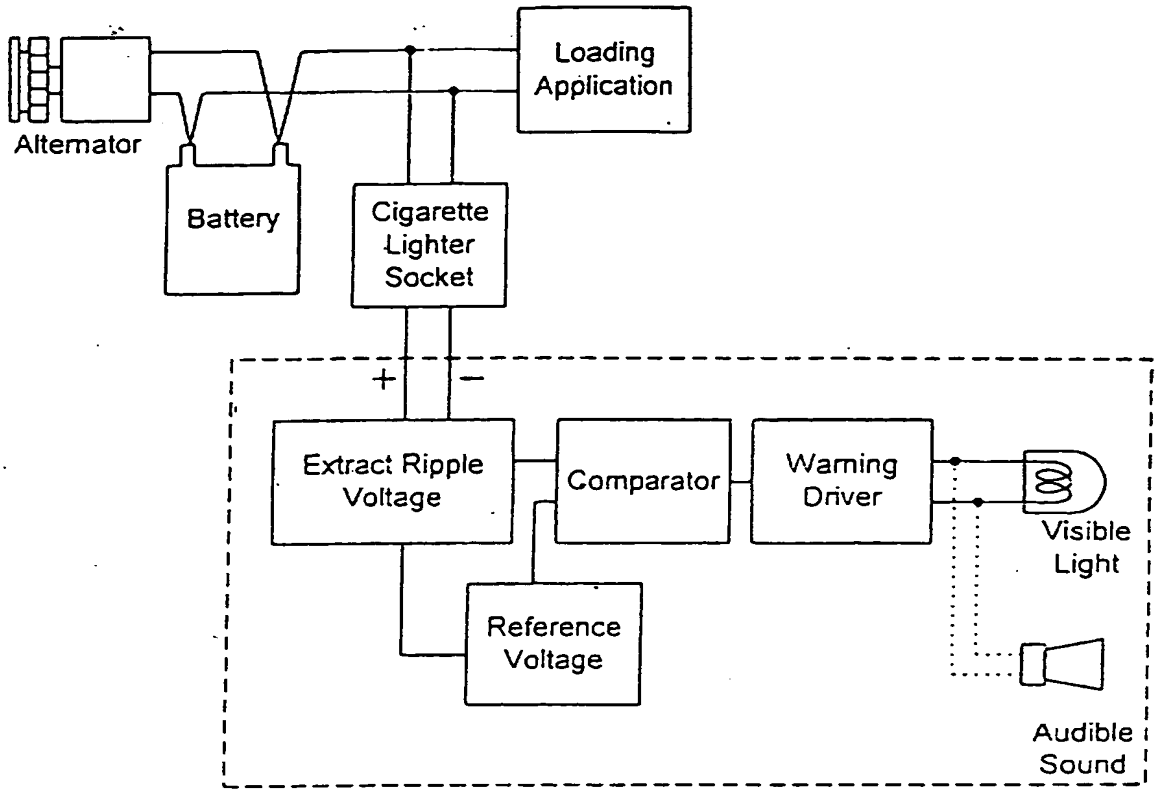


Figure 6



Automotive Battery Monitor Circuit Adapted for Car

Figure 7

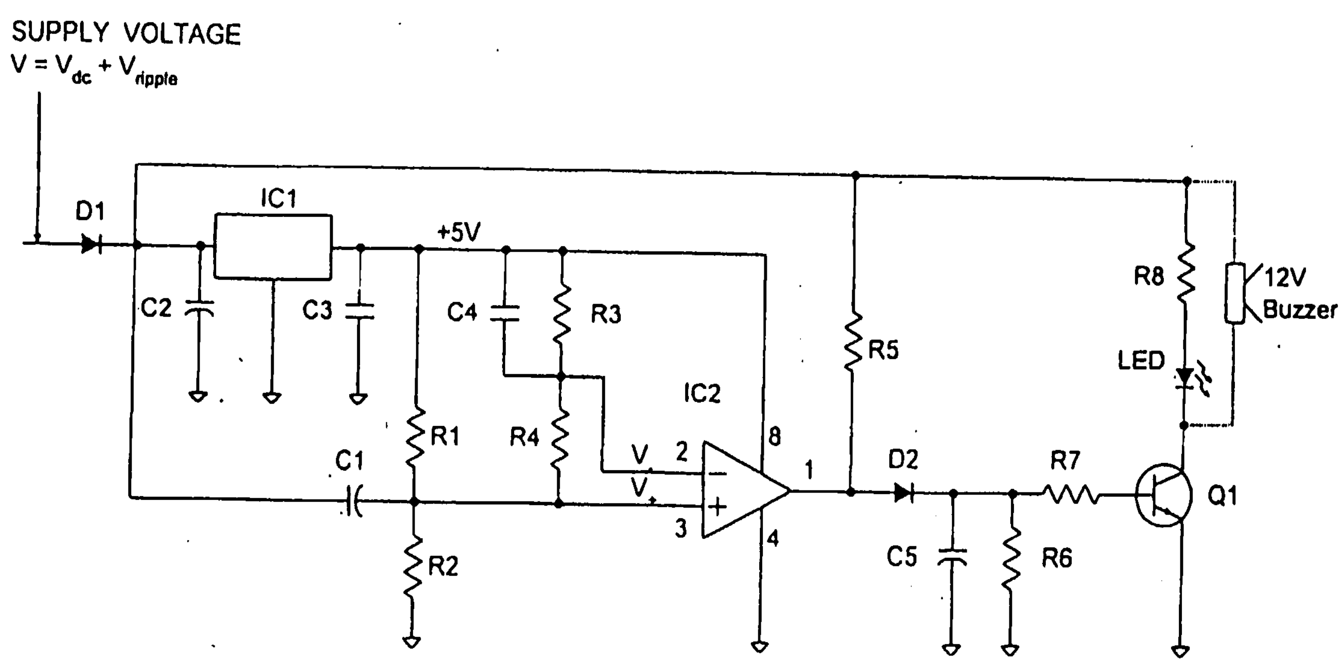
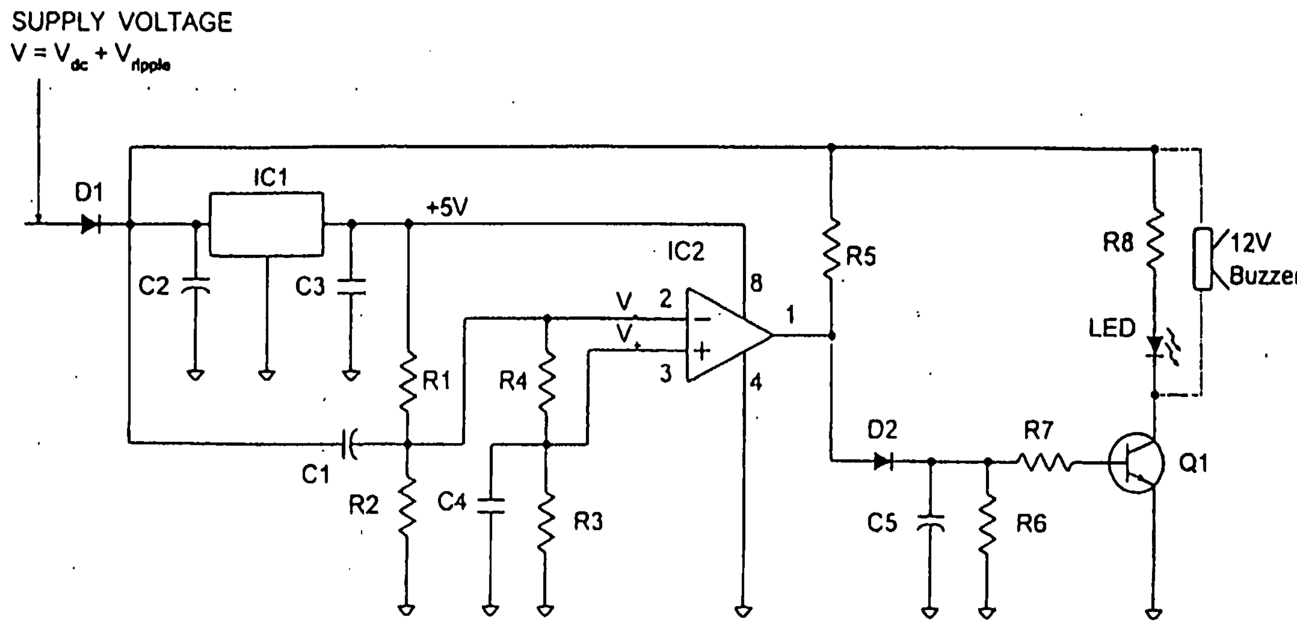

SUPPLY VOLTAGE
V = V_dc + V_ripple
D1
IC1
+5V
C2
C3
C4
R3
R5
R8
12V
Buzzer
LED
IC2
R1
R4
C1
V-
V+
2
3
8
1
4
D2
R7
Q1
C5
R6
R2

Figure 8


SUPPLY VOLTAGE
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V-
V+
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3
8
1
4
R5
R8
12V
Buzzer
LED
C1
R2
C4
R3
D2
R7
Q1
C5
R6

Figure 9

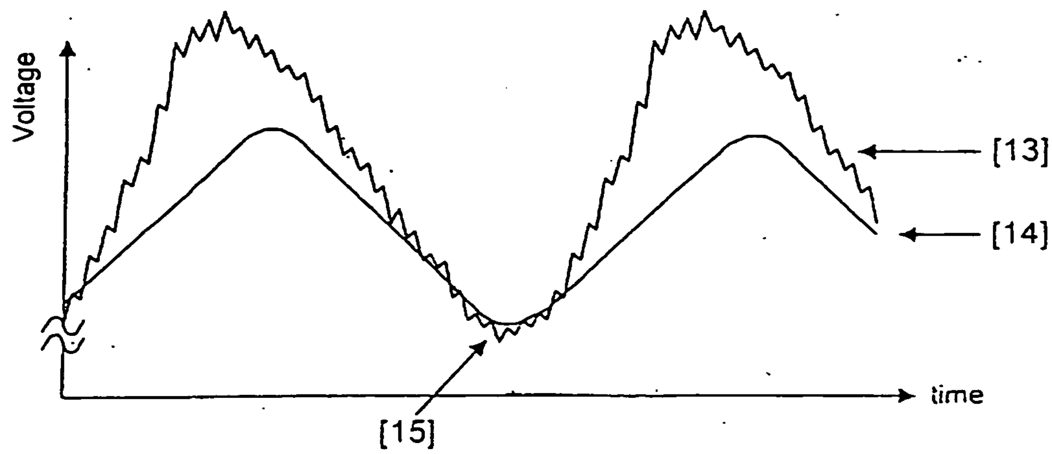
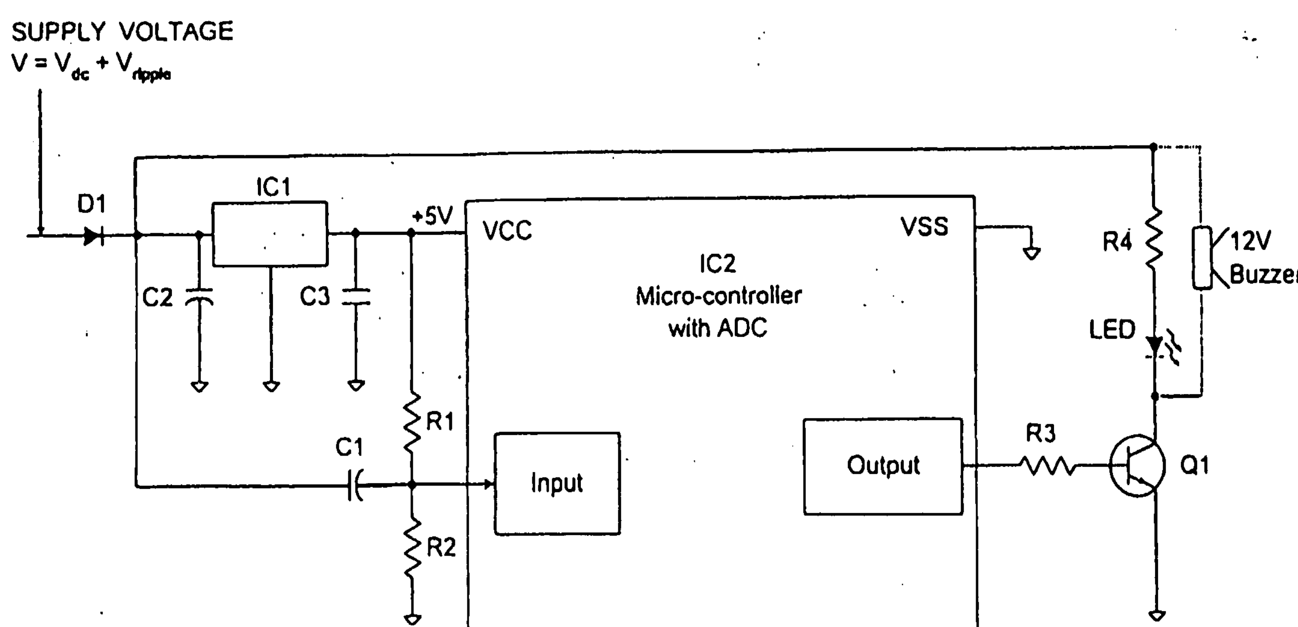


Figure 10



SUPPLY VOLTAGE
V = Vdc + Vripple
D1
IC1
C2
C3
+5V
VCC
VSS
IC2
Micro-controller
with ADC
R1
C1
Input
R2
Output
R3
Q1
R4
LED
12V
Buzzer

Figure 11

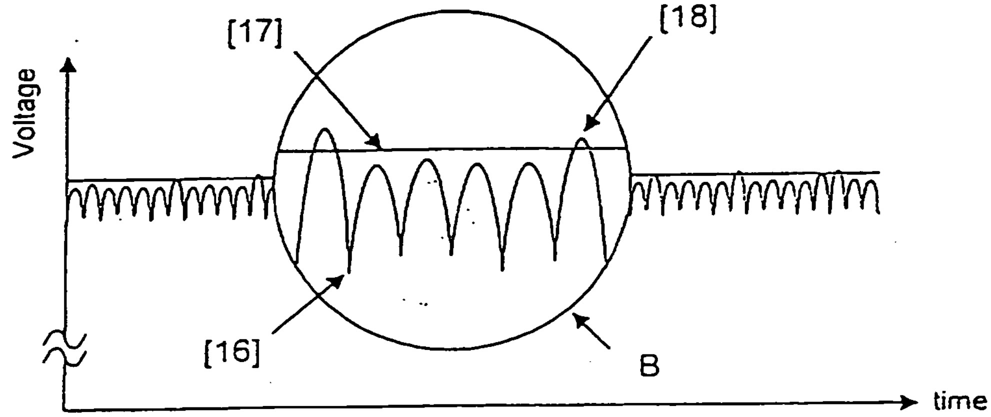


Figure 12

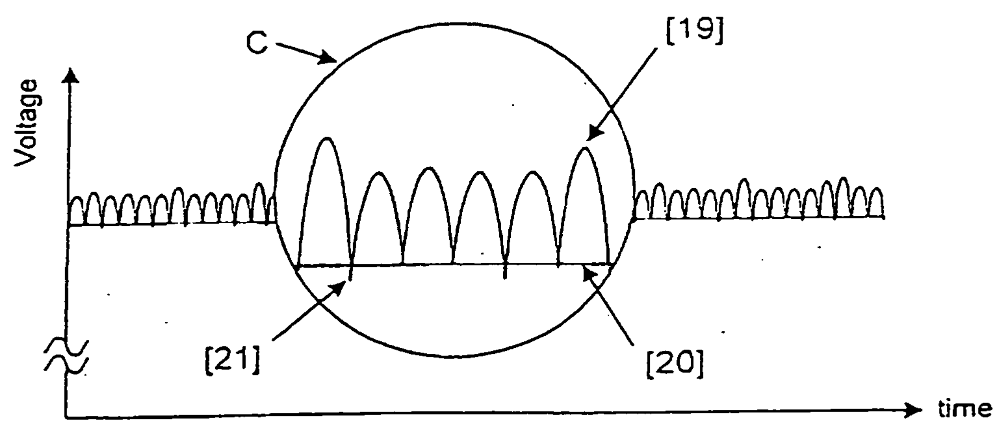


Figure 13

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METHOD AND APPARATUS FOR AUTOMOTIVE BATTERY CONDITION INDICATION

This invention relates to the field of battery monitoring systems. It is particularly suitable for automotive battery monitoring.

In the automotive industry, the location of the battery is usually concealed from direct access by users, being next to an engine covered by a bonnet, underneath the seat, or hidden in a casing. Some effort is needed to regularly access the battery for visual inspection and physical testing. If the battery deteriorates without any form of inspection or monitoring, the only time the user finds out about the deterioration is when the vehicle fails to function. For example, if the battery in a car has deteriorated through time one day the condition of the battery is so bad that the car fails to start. This can have serious financial, safety and time consequences to the applicants, depending on when and where the incident happens.

A purpose of the present invention is to assist users in monitoring the condition of a battery in an automotive vehicle. The automotive battery is typically concealed from direct user access. Due to their limited level of technical understanding and knowledge, it is very inconvenient, annoying and troublesome to most users that they would have to regularly remove the casing to reveal the battery and visually inspect liquid electrolyte and plate condition of the battery. Maintenance-free automotive batteries cannot be visually inspected to determine the condition of liquid electrolyte level and plate condition. In most cases, the users have no technical knowledge and equipment to even check the condition of maintenance-free automotive batteries. A known method is to isolate the maintenance-free automotive battery from the vehicle and to use a special charge-level test instrument that applies a load to the said battery. Such an instrument is expensive and usually found only in automotive workshops. By applying load to the battery, the condition of the battery can be known quite accurately, but with the expense of further degrading the condition of the battery.

Because of constraints imposed by inspection method, unit cost and installation processes, it has not been commercially acceptable to attempt to provide automotive battery condition indication using a conventional battery loading test method while

eliminating the need to physically inspect the battery. The present invention provides an apparatus to monitor and indicate automotive battery conditions, such as liquid electrolyte level, stored charge level and plate condition, using ripple voltage present in the battery supply line, and therefore not degrading the automotive battery in the process.

It is the prime objective of the preferred embodiment of the present invention to monitor and indicate the condition of an automotive battery, such as affected by for example the liquid-electrolyte level and battery plate deterioration, while eliminating the inconveniences and annoyance of visually inspecting the battery or isolating the battery for a loading test.

An automotive battery, once installed, is securely fastened to a battery supply line. When electrical current is supplied into the battery from a battery-charging system, namely an alternator, a ripple voltage component is generated onto the existing direct current, herein abbreviated as DC, voltage of said battery. Conversely, when electrical current is drawn from the said battery by electrical or electronic equipment in the vehicle, ripple voltage is also induced onto the existing DC voltage of said battery. The characteristics, namely shape and amplitude, of the ripple voltage may vary from one vehicle to another. The amplitude of ripple voltage is further dependant upon the condition of said battery, as affected by liquid electrolyte level, battery plate deterioration and battery terminal contact condition. As the condition of the battery deteriorates, the amplitude and/or the shape of the ripple voltage changes. By measuring these parameters, the condition of the battery can be monitored. The automotive battery condition indication circuit can either use the positive side, negative side or both sides of ripple voltage to determine the condition of said battery.

By monitoring the ripple voltage in the battery supply line, the user may obtain vital information about the condition of said battery without having to physically gain access to and inspect the said battery.

In one form, the invention is a method of in-situ monitoring of the condition of a storage battery in its operating environment when connected to other apparatus, comprising monitoring a ripple voltage present in a voltage across the battery, and comparing the ripple voltage with a reference characteristic to determine the condition

of the battery.

In another form the invention provides a method to monitor and indicate the condition of an automotive battery utilizing:-

(i) ripple voltage present in automotive battery supply line during engine running; and

(ii) ripple voltage characteristic comparison reference for comparing with the characteristics of said ripple voltage to determine the condition of said automotive battery.

The battery may be a lead-acid battery. The ripple voltage may refer to voltage generated by an alternator and electrical loads during running of an engine to which the battery is connected, multiple alternating-current components of differing amplitudes being present. The ripple voltage may be measured on a battery supply line which is an electrical wiring connection between the battery, the alternator and the electrical loads. The electrical wiring connection may include fuses, switches and relay contacts therebetween.

The tracking reference voltage may represent a non-varying direct-current reference point, or be a reference point that changes with respect to ripple voltage present during running of an engine to which the battery is connected. The tracking reference voltage may be a voltage signal or digital data within a microcontroller, and may have an amplitude or shape on either the positive side or the negative side, or on both sides, of the ripple voltage.

The invention also provides apparatus to effect the method of the invention.

Thus, in another form, the invention is an apparatus to monitor the condition of a battery, when in-situ and connected in its operating environment, the apparatus comprising means for monitoring a ripple voltage present in a voltage across the battery; and means for comparing the ripple voltage with a reference characteristic to determine the condition of the battery.

Other preferred features of the present invention are as set out in the subordinate claims.

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 illustrates a general battery system embodying the present invention.

Figure 2 illustrates the example plot of a typical voltage waveform in an automotive battery supply line with reference to a OV-supply line when the engine is running.

Figure 3 illustrates the detailed zoom-in on the voltage waveform, circled "A", in figure 2.

Figure 4 illustrates an automotive vehicle, such as a car, embodying the present invention through a cigarette lighter socket built into the car, and indicates condition through a combination meter.

Figure 5 illustrates a sample ripple voltage present in the battery supply line of a car using a well-conditioned battery having a positive-tracking reference voltage.

Figure 6 illustrates a sample ripple voltage present in the battery supply line of a car using a deteriorated battery having a positive-tracking reference voltage.

Figure 7 illustrates a block diagram of a system adapted for implementing a battery monitor circuit embodying the present invention in a car through a cigarette lighter socket.

Figure 8 illustrates details of a circuit adapted for use in the automotive battery condition indicator of car based on positive ripple voltage characteristics.

Figure 9 illustrates details of a circuit adapted for use in the automotive battery condition indicator of car based on negative ripple voltage characteristics.

Figure 10 illustrates the ripple voltage present in the battery supply line of a car using a deteriorated battery for purposes of the circuit illustrates in Figure 9.

Figure 11 illustrates details of a circuit adapted for the automotive battery condition indicator of a car using a micro-controller with an internal analog-to-digital converter (ADC).

Figure 12 illustrates the ripple voltage, extracted and modified from the ripple voltage present in the battery supply line of a car using a deteriorated battery, for the circuit illustrated in Figure 8 based on positive ripple voltage characteristics.

Figure 13 illustrates the ripple voltage, extracted and modified from ripple voltage present in the battery supply line of a car using a deteriorated battery, for the circuit illustrated in Figure 9 based on negative ripple voltage characteristics.

For ease of reference, the following is a list of the features appearing in the drawings:

1. Circuit Adopting Present Invention
2. Automotive Battery
3. Alternator/Charger
4. Battery Supply Line
5. Electrical Load
6. Cigarette Lighter Socket
7. Combination Meter
8. Tracking Reference Voltage 1
9. Ripple Voltage 1
10. Tracking Reference Voltage 2
11. Ripple Voltage 2
12. Ripple Cross-over Region 2
13. Ripple Voltage 3
14. Tracking Reference Voltage 3
15. Ripple Cross-over Region 3
16. Modified Ripple Voltage 4
17. DC Reference Voltage 4
18. Ripple Cross-over Region 4
19. Modified Ripple Voltage 5
20. DC Reference Voltage 5
21. Ripple Cross-over Region 5

Referring first to Figure 1 of the drawings, automotive battery condition indicating circuit [1] is generally attached directly across battery supply line [4]. The said battery monitoring circuit [1] monitors the ripple voltage component present in battery supply line [4] created either by the battery charging system [3], namely an alternator, or the load [5], for instance, electrical or electronic devices. In this particular illustrated embodiment of the present invention, the battery charging system [3] is connected directly to the battery [2]. The voltage in battery supply line [4], shown in Figure 2, has a ripple voltage component added to the existing DC voltage of the said battery [2]; a zoom-in on the voltage waveform is shown in Figure 3. The condition of said battery [2] could be deduced from the characteristics, namely, the shape and amplitude of the ripple voltage.

In its broadest terms, the present invention is applicable to any automotive battery in any automotive vehicle. It may be utilized in a car such as that illustrated in Figure 4. This system comprises a lead-acid battery [2], an alternator [3] and all other electrical and electronic loads such as an air condition fan and a compressor, water tank cooling fan, engine starter motor, lamps, electronic anti-theft alarm system, radio and etc. Battery condition indication circuit [1] embodying the present invention

can either be built permanently into the car and indicate battery condition within combination meter [7], or be designed as a portable device connected to a cigarette lighter socket [6] which is connected to battery supply line [4]. When the engine of the car is started, charging system/alternator [3], connected to a load [5], will produce a voltage comprising of DC and ripple voltage components. A well-conditioned battery [2], acting like a large-capacity capacitor, filters the ripple voltage component down to a small amplitude ripple voltage. A sample is shown as ripple voltage [9] in Figure 5. Conversely, a poorly conditioned battery [2], acting like a small-capacity capacitor, cannot filter the ripple voltage as well as a well-conditioned battery. This results in a large-amplitude ripple voltage [11], as shown in Figure 6.

In one adaptation of a battery condition indicating circuit [1], for a car in Figure 4 using cigarette lighter socket [6], a slowly varying reference voltage [8] that tracks the positive side of ripple voltage [9] is used to determine the condition of automotive battery [2], as shown in Figure 5. Since the amplitude of ripple voltage [9] is small, the tracking reference voltage [8] is capable of tracking the ripple voltage [9]. Conversely, when amplitude of ripple voltage is large, the slowly varying reference voltage [10] is unable to track the rapidly changing ripple voltage [11]. This resulted in the ripple voltage [11] crossing over the tracking reference voltage [10] at region marked [12]. Therefore, by choosing the right tracking characteristics of a varying reference voltage, the battery condition indicating circuit [1] can be fine-tuned to suit different cars. Figure 7 shows a block diagram of a system embodying a battery condition indicating circuit [1] of the present invention, implemented in Figure 4 using cigarette lighter socket [6].

Referring to Figure 8, supply voltage on battery supply line [4], V, is a combination of DC voltage component, V_{DC} and ripple voltage component, V_{ripple}. Diode D1 protects the circuit from inverse supply-voltage polarity. 5V fixed voltage regulator IC1, capacitor C2 and C3 provide a 5.0V nominal DC voltage supply to operate other circuits. Resistors R1, R2 and electrolyic capacitor C1 shift the DC component voltage of battery supply line, V, from 12V nominal to a lower voltage that is compatible to the circuit, say 2.5V, without altering the characteristics of the ripple voltage, V_{ripple}. The shape of ripple voltage, V_{ripple}, generated at circuit node V_+ (in

Figure 8) is shown as [9] and [11] in Figure 5 and 6 respectively. Resistors R3, R4 and multi-layer ceramic capacitor C4 from the tracking reference voltage using ripple voltage, V_{ripple}, at node V_+ (in Figure 8).. A sample shape of this tracking reference voltage at circuit node V (in Figure 8) is shown as [8] and [10] in Figure 5 and 6 respectively. IC2 compares voltage difference between V_+ and V_- and generates an active-high signal upon detecting a crossover region as illustrated as [12] in Figure 6 via pull-up resistor R5. Resistors R6 and R7, electrolytic capacitor C5 and diode D2 recondition signal from pin 1 of comparator IC2 to trigger on a warning indication driver, implemented as transistor Q1. Q1 in turn triggers a visual indicator implemented using resistor R8 and a Light Emitting Diode, herein abbreviated as LED.

A second modification is to use an audio indicator by replacing the resistor R8 and the LED with a 12V DC buzzer, shown as dotted connection in Figure 8.

A third modification, as shown in Figure 9, is to track the negative side of ripple voltage, V_{ripple}. This is achieved by rearranging resistor R3, R4, capacitor C4 and IC2. The comparison between the ripple voltage and tracking reference voltage is shown as [13] and [14] respectively in Figure 10. Region [15], in Figure 10, indicates that poor conditioned lead-acid battery produced a ripple voltage [13] that crossover tracking reference voltage [14].

A forth modification, as shown in Figure 11, is to use micro-controller IC2 with an internal Analog-to-Digital converter, herein abbreviated a ADC, to implement, using software, the functions of generating tracking reference voltage, comparing ripple voltage to reference voltage, and reconditioning the result of comparison before triggering an indication circuit. The micro-controller IC2 can be programmed to implement tracking of positive side, negative side or both sides of ripple voltage to reduce the condition of automotive battery [2].

Examples described above utilize the actual ripple voltage present in battery supply line [4] as shown in [9] and [13]. A fifth modification is to extract this ripple voltage and modify it to a simpler for shown as [16] in Figure 12. The same circuitry as in Figure 8 is adapted for this modification. The only difference is to reduce capacitance value of C1 and increase capacitance value of C4. In this modification, a low-capacitance C1 de-couples low-frequency components in the actual ripple voltage

present on battery supply line [4] to form a modified ripple voltage [16]. Large capacitance C4, in combination with R3 and R4, generates a DC reference voltage [17] for comparison to the positive side of modified ripple voltage [16]. Area B shows the enlargement plot of the modified ripple voltage [16] and DC reference voltage [17]. When a poorly conditioned automotive battery [2] was used, the modified ripple voltage [16] crossed over the DC reference voltage [17] at region [18]. Region [18] causes the comparator IC2 to signal detection of poorly conditioned automotive battery [2].

A sixth modification is to modify the fifth modification so as to use a DC reference voltage [20] for comparison to a negative side of modified ripple voltage [19], as shown in Figure 13. The same circuitry in Figure 9 is adapted for this modification. The only difference is to reduce the capacitance value of C1 and to increase the capacitance value of C4. Area C shows the enlargement plot of the modified ripple voltage [19] and DC reference voltage [20]. In this modification, when a poorly conditioned automotive battery [2] was used, modified ripple voltage [19] crossed over the DC reference voltage [20] at region [21]. Region [21] causes the comparator IC2 to signal detection of a poorly conditioned automotive battery [2].

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The text of the abstract filed herewith is repeated here as part of the specification.

The present invention concerns a system and an apparatus for monitoring the electrical condition of an automotive battery in use. The main purpose of this invention is to monitor and indicate automotive battery conditions, namely, liquid electrolyte level and level of battery plate deterioration using the concept of ripple voltage. Ripple voltage present in a battery supply is utilized as a reference to reduce the condition of the battery. The method comprises the steps of first measuring the ripple voltage present in the battery line when the engine is running, comparing the ripple voltage to a range of acceptable values, determined by the extent of battery deterioration, before issuing a signal or by nominal setting that best fits automotive

vehicles, and lastly providing an indication when the ripple voltage exceeds the range pre-set values. The apparatus comprises a ripple voltage detector, having the acceptable range setting, connected to the battery supply line, and an indicator connected to the ripple voltage detector which gives an indication when the ripple voltage exceeds the acceptable range setting.

CLAIMS:

1. A method of in-situ monitoring of the condition of a storage battery in its operating environment when connected to other apparatus, comprising monitoring a ripple voltage present in a voltage across the battery and comparing the ripple voltage with a reference characteristic to determine the condition of the battery.

2. A method as in claim 1, wherein the condition of the battery includes liquid electrolyte level, level of positive and negative plate deterioration, and terminal contact condition of the battery.

3. A method as in claim 1 or 2, wherein the battery is a lead-acid battery.

4. A method as in any one of the foregoing claims, wherein the ripple voltage is generated by an alternator and/or by electrical loads to which the battery is connected, multiple alternating-current components of differing amplitudes being present.

5. A method as in claim 4, wherein the ripple voltage is measured on a battery supply line which is an electrical wiring connection between the battery, the alternator and the electrical loads.

6. A method as in any one of the foregoing claims, wherein the reference characteristic is a non-varying DC reference or is a reference that changes with respect to the ripple voltage.

7. A method as claimed in claim 6, wherein the reference characteristic tracks the ripple voltage.

8. A method as claimed in claim 7, wherein the comparing means detects a reversal of the relative magnitudes of the ripple voltage and the reference characteristic.

9. A method as in claim 6, 7 or 8, wherein the tracking reference characteristic is a voltage signal or is digital data within a microcontroller.

10. A method as in claim 7, wherein the tracking reference characteristic is a voltage which has an amplitude or shape on either the positive side or the negative side or on both sides of the ripple voltage.

11. A method as in any one of the foregoing claims, wherein the battery is an automotive battery.

12. An apparatus to monitor the condition of a battery, when in-situ and connected in its operating environment, the apparatus comprising:

means for monitoring a ripple voltage present in a voltage across the battery; and,

means for comparing the ripple voltage with a reference characteristic to determine the condition of the battery.

13. An apparatus as in claim 10, wherein the apparatus is electrically-connected to a portion of a supply line of the battery.

14. An apparatus as in claim 12 or 13, wherein the battery is an automotive battery.

15. An apparatus as claimed in claim 12, 13 or 14, wherein the reference characteristic tracks the ripple voltage.

16. An apparatus as claimed in claim 15, wherein the comparing means detects a reversal of the relative magnitudes of the ripple voltage and the reference characteristic.

17. A method for monitoring and indicating the condition of a battery as herein described with reference to and as shown in any of Figures 1 to 13 of the accompanying drawings.

18. An apparatus to monitor and indicate the condition of a battery as herein described with reference to and as shown in any of Figures 1 to 13 of the accompanying drawings.

The Patent Office

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INVESTOR IN PEOPLE

Application No: GB 9922114.5
Claims searched: 1 - 18

Examiner: Anna Mackisack
Date of search: 19 November 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): G1U (UR3100 UR3136) H2K (KSX)

Int Cl (Ed.6): G01R 31/00 31/36

Other: Online: EPODOC JAPIO WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2271229 A	FPS POWER SYSTEMS - see abstract	1, 12
X	US 5744932	KISSEL - see especially column 3 lines 12 to 40	1, 12
X	JP 10 - 020002 A	JAPAN STORAGE BATTERY CO. - see also WPI Abstract Accession No. 98-149216/14	1, 12
A	JP 09 - 121472 A	JAPAN STORAGE BATTERY CO. - see also WPI Abstract Accession No. 97-308730/28	1, 12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.